Chapter 1

A DIGITAL MARKETPLACE FOR EDUCATION

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Abstract We describe a web-based Educational MarketPlace that matches student requests for learning materials to available and appropriate resources. We address technical issues such as: 1) resource acquisition and data mining techniques to facilitate access to large-scale educational repositories; 2) negotiation, contract execution and verification of instructional resources, and 3) digital repository testbeds to evaluate agent behavior. Societal issues include understanding web-based educational interactions, individual learning processes and organizational dynamics in the distributed, digital instructional realm. The Educational MarketPlace is different from other Internet spaces in that it requires independent scoring of resources and certification of teaching. This chapter discusses these issues and the open learning environment where a learner has choices; it describes how the Internet might replace the existing education monopoly and help dissolve the cottage industry of education in which a teacher handcrafts materials fixed by space and time.

1 PROBLEM STATEMENT

Many problems prevent people from obtaining maximal benefit from the Internet. Numerous resources exist, characterized by a great diversity in cost, prerequisites, quality, approach and availability. However, people cannot comprehend nor fully exploit the huge amount of available on-line knowledge; it surpasses the ability of people to locate, evaluate or manipulate. Thousands of resources exist and the environment is in constant flux, see Table 1. Currently, some resources might provide formal credentials, others simple knowledge and still others experience or training. The material varies in pedagogy and interactivity from intelligent tutors [Woolf & Hall, 1995; Beck et al., 2000], to simulations, hypermedia [Brusilovsky, 2000] and papers.

Table 1. Web-based Instructional Resources

Educational Resources on the Web
COURSES: E-College, www.ecollege.com, thousands of courses, one hundred degree programs CaliforniaVirtual University, www.cvc.edu, 1569 courses. Western Governor's University, www.wgu.edu, 275 courses. Southern Regional Education, www.-srec.sreb.org, 300 courses
OBJECTS: Educational Object Economy, www.eoe.org, 2600 learning objects NEEDS engineering database, www.needs.org, 863 Modules
INSTRUCTIONAL LIBRARIES: Chemistry, www.chem.ucla.edu/chempointers.html Mathematics, www.forum.swarthmore.edu
DATABASES NASA, www.nasa.gov/gallery/index.html Human Genome, www.ncbi.nlm.hih.gov/genemap99
CLEARING HOUSES, PORTALS, CHANNELS American Distance Education Consortium.www.deal.unl.edu The Gateway to Educational Materials, www.thegateway.org, Ask-ERIC, www.askeric.org Advanced Distributed Learning www.adlnet.org

For example, more than 27,000 college-level courses were delivered over the Internet and more than 1.6 million students enrolled in a distance education course in 1997-1998 [Boettcher, 2000]. Additionally, 53% of U.S. colleges offered distance education courses and an estimated 1,230 degree programs were designed to be completed totally through distance education. The number of institutions using Internet technologies tripled in the last three years and 82% of institutions queried said they would start using this method or increase their use of this method over the next three years [Boettcher, 2000]. As these numbers increase serious problems of efficiency will develop unless novel mechanisms are implemented to manage the resources and interaction.

In a well managed educational network, tools are needed to organize and manage these resources. For instance, a query from a student changing majors might elicit a schedule of tailored resources, containing only that student's course deficiencies, a pre-medical student might receive a college course, combined with quizzing module and real-time experimental-data, and a visually handicapped student might receive only spoken software. The educational network should use student modeling and machine learning techniques to assemble and tailor resources. The student should be able to access classes of objects, distributed across heterogeneous repositories and customized by mediating software that compensates for site-by-site variations.

2 EDUCATION AS E-COMMERCE

Universities enjoy a monopoly on higher education, which is maintained as a cottage industry, with faulty handcrafting courses from scratch and delivering made-to-order programs to an audience fixed in time and space. Constraints of geography and time and certification through awarding degrees have reinforced this monopoly [Dunderstadt, 1997].

The tremendous impact of the Internet is helping dissolve this monopoly, while eliminating the constraints of time and space. It is creating open learning environments in which the learner has a choice in the marketplace. Individual handcrafted courses are being challenged by the increasing demand for advanced education and the expanding digital environment, which attracts new competitors, exploiting new paradigms and threatening traditional providers.

Through the Internet, education will become learner- and goal-oriented rather than faculty-centered. Evolution towards the learner is both evident and irresistible [Dunderstadt, 1997]. Why would students choose to take classes from the local professor when they can take classes with global experts? The outstanding local professor, teaching a unique or hands-on course or providing a strong experience, will continue to draw a following. However, other types of learning will become a "commodity" provided to anyone anywhere for a price. In effect, the customer pull (student demand) will obtain effective influence over a market that for 600 years has been shaped only by producer push (instructor offerings).

Most faculty are not adept at "packaging" content for mass audiences, even though some write textbooks, which are typically marketed and distributed by publishers. Faculty are skilled at creating content for their lecture-based programs. Universities have begun to use the web to outsource production and distribution of courses by those most experienced in reaching large populations of students.

Higher education in the U.S.A. is already a $175 billion-a-year enterprise and has spawned new players such as virtual universities and for-profit organizations to take advantage of the market interest [Dunderstadt, 1997]. Like other "deregulated" industries, e.g., healthcare or communications, education is evolving. As the global society becomes ever more dependent upon new knowledge, educated people and knowledge workers, the global knowledge business must be viewed as one of the most active growth industries of our times. As a result of E-commerce, higher education is evolving from a loosely federated system of colleges and universities into a global knowledge and learning industry.

From the viewpoint of venture capitalists, education is one of the most fertile new markets for investors. It has a combination of large size (approximately the same size as health care), disgruntled users, lower utilization of technology, an extremely labor intensive workforce and possibly the highest strategic importance of any activity in which global countries engage. Additionally, existing management are sleepy after years of monopoly [Dunderstadt, 1997].

3 PROPOSED SOLUTION

Many technical and social barriers need to be addressed before education becomes an open global learning marketplace supported by the web. For example, technology must be developed to harness and structure millions of web-based educational resources. Software must provide accurate and efficient access to large collections of instructional resources. Achieving this requires breakthroughs in the description, representation and retrieval of resources, agent technology, marketplace exception handling mechanisms and student modeling. Issues include assembly and disassembly of resources, negotiation over multi-leveled issues, identification of pedagogical pre- and post-conditions, and creation of student and knowledge models that persist for a lifetime, improve over time and maintain privacy.

We are building an Education Network, or E-Net, that contains classes of agents representing students and resources, see Table 2. These components are described in Section 6. Information retrieval techniques are being integrated into a digital marketplace that represents and delivers instructional

Table 2. Components of E-Net

Component	Target Capability	Technology
Student Agents	Monitor course plans, record student model, interact with student and supervise negotiation.	Student modeling in interactive systems
Search Bots (SB)	Search web for pedagogical agents; standardize terms.	Information retrieval
Course Assembly (CAA)	Assemble and build plans from resources offered by other agents. Negotiate, collect bids, form contracts.	Planners, fuzzy operators; machine learning
Pedagogical Agents	Represent instructional resources. Negotiate contracts with student agents.	Pedagogical modeling, economic modeling
Resource Agents (RA)	Provide wrappers for one or more resources.	Provide a set of simple shells for wrapping common types of resources.
Resource Classifiers (RC)	Creates models of resources using standards to enable resources to be wrapped.	Machine learning to gauge effectiveness of resources, reduce overtime; Automatically find pre- and post- conditions
MarketPlace	Enable the assembly of resources.	Manage large dynamic open systems; develop market institutions; help anticipate, avoid and detect non-compliant resources.

material, manages the tangled web of resources and students and respects the privacy of students. Authors of educational resources will be encouraged to contact E-Net to register their resources into the marketplace, but E-Net will also actively search for and incorporate resources without any specific action by developers.

E-Net will dynamically support learners in the selection and management of instructional resources. It will enable students to better exploit the vast quantity of knowledge distributed across the Internet. E-Net will accept queries of three types: Level 1: Classical course request–"I need to refresh my calculus in preparation for the physics 101 course next week." Level 2: Multi-disciplinary query–" I want a summer long course in biomedical engineering." Level 3: Highly focused topic–"I need to model turbulence using computational fluid dynamics."

4 EXISTING SOLUTIONS TO THE PROBLEM

No current research addresses these concerns. Many commercial and academic organizations have built thousands of web resources characterized by student age, cost, learning types, etc. (see Table 1), but no technology exists to search, retrieve, tailor, schedule, deliver and evaluate resources within a standardized environment with a safety net provided by the marketplace.

Many Internet marketplaces exist. However, this marketplace is different requiring several new components and capabilities.

1) Independent Scoring of Resources. The typical virtual marketplace does not distinguish between agents of greater or lesser use – all goods and services with the same description are assumed to be identical for the purposes of matchmaking between the constituent agents. This may be acceptable where the goods of trade, such as cars or airplane tickets, are in fact interchangeable, or at least where the differences can be tolerated; but where this is not the case, exception handling is needed. The instructional marketplace will provide a mechanism for differentiating between educational resources with similar descriptions on the basis of their performance. In most cases the educational resources will be scored automatically by the system, based on information provided by the other resources that interact with the same student.

2) Certification/Reputation Agency. Current marketplaces accept all new resources. The education marketplace can only support certified resources. To allow student agents to confidently contract with new resources, the instructional marketplace will provide a certification service whereby any new active tutoring system will require an endorsement by independent human professionals. (For example, two or three endorsements by teachers who use the service.)

3) Contract Fulfillment. In a perfect world we can rely on agents to be honest and always tell the full truth; in the real world, and particularly where

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